LANL announces top 10 science stories of 2009

January 8, 2010

Los Alamos achievements from supercomputing to biofuels

Los Alamos, New Mexico, January 8, 2010—Los Alamos National Laboratory has identified the Top 10 Laboratory science stories of 2009 based on global viewership of online media content and major programmatic milestones.

“Often our top breakthroughs in terms of scientific impact are also the ones that garner the most attention in the media,” said Terry Wallace, Laboratory principal associate director of science, technology, and engineering. “This was certainly the case for Roadrunner and for the Ardi discovery. Sometimes, the best measure of impact is programmatic, such as the successful DARHT two-axis hydrotest, or our teams using nanotechnology for energy breakthroughs. In combination, this collection of advances points to the diverse capabilities at Los Alamos that we harness for national security science.” Much of the science and technology at Los Alamos stems from or benefits the Lab’s key national security mission performed for the National Nuclear Security Administration.

The Top 10 LANL Science Stories for 2009 are:

#1) Roadrunner: The Roadrunner supercomputer at Los Alamos is the first computing system in the world to reach a petaflop, computer jargon for 1 million billion calculations per second, a record that stood for a year and a half. But the real accomplishment is that Roadrunner reached that goal using an entirely new computing architecture. The secret to its record-breaking performance is a unique hybrid design. The full system consists of 278 server racks containing 6,562 AMD Opteron™ dual-core processors and 12,240 PowerXCell 8i™ Cell processors, a special IBM-developed variant of the Cell processor used in the PlayStation®3. The node-attached Cell accelerators are what make Roadrunner completely different than typical computing “clusters.” Roadrunner also is one of the most energy efficient supercomputers. Using approximately 3 megawatts of power at sustained petaflop performance, the system produces about 500 megaflops per watt, more than twice the efficiency of the average supercomputer.

#2) Ardi: A Los Alamos National Laboratory geologist is part of an international research team responsible for discovering the oldest nearly intact skeleton of Ardipithecus ramidus, who lived 4.4 million years ago. The discovery reveals the biology of the first stage of human evolution better than anything seen to date. The fossil, nicknamed

“Ardi,” is the earliest skeleton known from the human branch of the primate family tree. The discovery provides new insights about how hominids—the family of “great apes” comprising humans, chimpanzees, gorillas, and orangutans—may have emerged from an ancestral ape. The discovery and associated research were named Science magazine’s Breakthrough of the Year for 2009 and selected by Time magazine as the #1 science story of 2009.

#3) Climate modeling & monitoring: LANL innovations in high-resolution climate modeling and monitoring led to new insights into the impacts of climate change at global and regional scales.

The changing conditions in the ocean due to increased acidity from increased CO_2 is one of the unknowns in future climate change projections. LANL’s Climate, Ocean, and Sea Ice Modeling effort for DOE and the National Science Foundation develops the highest-resolution dynamic models of the world’s oceans and polar icecaps. Although up to 80 percent of the world’s oxygen is generated by photosynthetic processes in ocean phytoplankton and other sea plants, the effects of this photosynthesis on removing CO_2 from the atmosphere have not been included previously because of the lack of available computing power. Harnessing the petaflop capacity of LANL’s Roadrunner supercomputer (see #1 above), Lab researchers recently examined the effect of mesoscale ocean eddies (a few miles in size) on the transport of nutrients crucial for the growth of phytoplankton. These eddies cause vertical transport of nutrients, which is crucial for the growth of phytoplankton. The model can then calculate surface chlorophyll concentrations, and compare to satellite images. This model is dramatically better than the previous state of the art in resolution and its ability to capture biological complexity.

The regional effects of global climate change on western U.S. forests also are important to understanding future impacts, especially as forests comprise an important CO_2 sink. The widespread die-off of piñon trees in the southwest is now being followed by a larger-scale pine mortality in the mountain west. LANL scientists documented a new mechanism for this mortality, called carbon starvation. It has been widely presumed that trees die of hydraulic failure (drying out). Instead, they die from closure of the tiny pores on the surfaces of leaves that permit the exchange of gases between the atmosphere and the leaf. When the pores are closed (to prevent water loss during extreme drought), the photosynthetic uptake of carbon also stops, starving the trees. This type of mortality has been documented on all six vegetated continents and is increasing, with climate change, across all biomes (forest, desert, grasslands, tundra, and aquatic ecosystems). This work is an enormous step forward in demonstrating that regional climate change drives a global-scale response of vegetation mortality. Massive forest die-offs can change vegetated areas from carbon sinks to carbon sources.

#4) MagViz: LANL’s MagViz team pioneered the use of modified magnetic resonance imagery (MRI) technology to distinguish and alert airport security staff to potentially dangerous liquids and gels in airport carry-on baggage. Using extremely low magnetic fields and high-powered computer analysis, the MagViz equipment was demonstrated for its Department of Homeland Security sponsors and potential Transportation Safety Administration users at the Albuquerque International Sunport (http://www.youtube.com/LosAlamosNationalLab#p/a/u/4/xT2zncrtU-s). A new area of development is a bottled-liquid scanner system based on the same technology.

#5) First dual-axis hydrodynamic test: LANL scientists and engineers fired the first-ever double-viewpoint, multiframe hydrodynamic test at DARHT, the Laboratory’s

Dual Axis Radiographic Hydrodynamic Test facility – leading to future experiments at LANL and across the nation's nuclear security enterprise, supporting the stockpile stewardship and weapons assurance mission. "Initial data return was excellent," said the hydrodynamic experiments division leader, David Funk. "The baseline experiment captured five time-dependent X-ray images and a variety of data from other diagnostics of pressure, temperature, and timing. This data provides the nation with one of the most rigorous tests of our capability to predict weapons performance."

#6) Hurricane prediction: A system of sensors developed by Los Alamos National Laboratory for the National Nuclear Security Administration's nonproliferation mission has also begun to give meteorologists their most detailed view of the relationship between hurricanes and lightning. By examining the rate and nature of lightning in the hurricane's eye wall, scientists may begin to be able to predict the potential strengthening of these destructive storms.

#7) Fuel from plants: Los Alamos National Laboratory has teamed with Solix Biofuels, Inc. to use an award-winning LANL sound-wave technology to optimize production of algae-based fuel in a cost-effective, scalable, and environmentally benign fashion. Acoustic focusing—the novel use of sound waves at the heart of the Los Alamos Acoustic Flow Cytometer, a 2007 R&D 100 Award-winning technology—is being commercialized in partnership with Solix to harvest biocrude, or "green gold," an alternative to crude oil that can be refined into biodiesel, gasoline, or even jet fuel. The technology is to be deployed in 2010 to Solix's Coyote Gulch Demonstration Facility near Durango, Colorado, for real-world production of lower-cost biofuel.

In addition, research breakthroughs using the LANL Protein Crystallography Station (part of the Lab's LANSCE facility) to probe the structure of cellulose are making the prospect of affordable, efficient production of cellulosic fuels closer to reality. The Protein Crystallography Station is the only resource of its kind in the United States and the first protein crystallography beam line to be built at a spallation neutron source.

#8) IBEX: The invisible structures of space are becoming less so, as scientists look out to the far edges of the solar wind bubble that separates our solar system from the interstellar cloud through which it flies. Using the High Energy Neutral Atom Imager, led by LANL, the NASA Interstellar Boundary Explorer (IBEX) mission (http://www.nasa.gov/mission_pages/ibex/index.html) has sent back data that indicates a "noodle soup" of solar material has accumulated at the outer fringes of the heliosphere bubble. The Los Alamos camera detects particles that are heated and stream away from that boundary, specifically the density and temperature of atoms that form the core of that layer.

#9) Laser-particle acceleration for cancer therapy: Laser-particle acceleration is an emerging area of physics expected to enable significant future advances in cancer radiotherapy. An international team of physicists led by LANL has accelerated protons to world-record high energies that otherwise only achievable with large accelerator facilities. Proton radiation at the achieved energy range can be used, for example, to treat eye cancer. The new record-proton-acceleration energies were demonstrated at LANL's Trident facility—the world's highest-contrast, high-intensity, high-energy laser. Physicists bombarded specially designed thin films created using nanotechnology with short bursts of laser energy. The electric fields generated from this bombardment were used to accelerate protons to energies higher than ever before achieved—capable of destroying cancer cells.

#10) Nanotechnology for Energy Frontiers: Two LANL teams were awarded lead roles as DOE Energy Frontier Research Centers to develop new materials for energy.

The Center for Advanced Solar Photophysics will capitalize on recent advances in the science of how nanoparticles interact with light to design highly efficient materials for the conversion of sunlight into electricity. The purpose of this EFRC is to develop novel physics, materials, and architectures for harvesting solar light and converting it into electrical charges with efficiencies above equilibrium thermodynamic limits. Such materials can boost the efficiency of solar-energy conversion.

The Center for Extreme Environment-Tolerant Materials has as its objective to understand, at the atomic scale, the behavior of materials subject to extreme radiation doses and mechanical stress in order to synthesize new materials that can tolerate such conditions. This EFRC will develop a fundamental understanding of how atomic structure and interfaces contribute to defect and damage evolution in materials, with such potential applications as structural materials, fuel cladding, and waste forms in the next generation of nuclear power reactors and structural materials in transportation, energy, and defense.